

*[Handwritten mark: A bracket with "Preliminary" written inside.]*

We Claim:

1. A Planar inverted-F Antenna (PIFA) comprising:  
a top plate, a ground plane, a dielectric material  
between the top plate and the ground plane, and a feed pin  
5 connected to the top plate;  
a first shorting pin and a second shorting pin,  
the first and second shorting pins connecting the top plate  
to the ground plane and being located at distances  $p_1$  and  $p_2$ ,  
respectively, from the feed pin to provide a desired  
10 impedance of the PIFA at the feed pin.
2. The PIFA of claim 1, wherein the feed pin is  
connected to a transmission line, the transmission line  
being used for fine-tuning of the PIFA.  
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3. The PIFA of claim 1, wherein the transmission line  
is connected to a power amplifier.
4. The PIFA of claim 1 whereby a power amplifier is  
20 connected to the feed pin.
5. The PIFA of claim 4, wherein the power amplifier  
is a broadband power amplifier.
- 25 6. The PIFA of claim 1, wherein  $p_1$  and  $p_2$  are  
substantially equal.
7. The PIFA of claim 1, wherein the top plate is  
rectangular.

8. The PIFA of claim 1, wherein an imaginary line between the feed pin and the shorting pins forms substantially a right angle.

5 9. The PIFA of claim 1, wherein the dielectric material is air.

10. The PIFA of claim 1, wherein the dielectric material is epoxy/glass.

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11. The PIFA of claim 1, wherein the dielectric material is alumina.

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12. The PIFA of claim 1, wherein the dielectric material is quartz.

13. The PIFA of claim 1, wherein the dielectric material is polytetra fluoroethylene.

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14. The PIFA of claim 1 tuned at an operating frequency  $f_0$  and providing a class-F load impedance.

15. The PIFA of claim 1 tuned at an operating frequency  $f_0$  and providing an inverse class-F load impedance.

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16. The PIFA of claim 2 wherein the transmission line is connected to a power amplifier.

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17. The PIFA of claim 16, wherein the power amplifier is a broadband power amplifier.

18. A method of tuning a planar inverted-F antenna (PIFA) to operate at an operating frequency  $f_0$  and to provide

a class-F impedance, the PIFA having a top plate, a ground plane, a feed pin, a transmission line connected to the feed pin, a first shorting pin and a second shorting pin, the shorting pins connecting the top plate to the ground plane,

5 the method comprising the steps of:

a) varying the position of the top plate to locate the feed pin at or near the center of the top plate;

b) varying the distance  $\rho$  between the first and second shorting pins and the feed pin, thereby changing the  
10 real part of the input impedance of the PIFA;

c) varying the height of the top plate above the ground plane to change the real part of the input impedance of the PIFA, while respectively changing the imaginary part of the input impedance of the PIFA; and

15 d) adjusting the length of the transmission line to fine tune the input impedance of the PIFA at  $f_0$  and to maintain the desired harmonic loading at the second and third harmonics of  $f_0$ .

20 19. A method of tuning a planar inverted-F antenna (PIFA) to operate at an operating frequency  $f_0$  and to provide a inverse class-F impedance, the PIFA having a top plate, a ground plane, a feed pin, a transmission line connected to the feed pin, a first shorting pin and a second shorting pin, the shorting pins connecting the top plate to the  
25 ground plane, the method comprising the steps of:

a) varying the top plate position so that the feed pin is a maximal distance away from the center of the top plate;

30 b) varying the distance  $\rho$  between the first and second shorting pins and the feed pin thereby changing the real part of the input impedance of the PIFA;

c) varying the height of the top plate above the ground plane to change the real part of the input impedance of the PIFA, while respectively changing the imaginary part of the input impedance of the PIFA; and

5 d) adjusting the length of the transmission line to fine tune the input impedance of the PIFA at  $f_0$  and to maintain the desired harmonic loading at the second and third harmonics of  $f_0$ .

10 20. A method of tuning a planar inverted-F antenna (PIFA) from a first operating frequency  $f_0$  to a second operating frequency  $f_1$ , the PIFA having a top plate, a ground plane, a feed pin, a transmission line connected to the feed pin, a first shorting pin and a second shorting pin, the  
15 shorting pins connecting the top plate to the ground plane, the method comprising the steps of:

a) scaling the height of the top plate above the ground plane by a factor of  $f_0/f_1$ ;

b) scaling  $\rho$  by a factor of  $f_0/f_1$ ;

20 c) scaling the area of the top plate by a factor of  $(f_0/f_1)^2$ ; and

d) scaling the length of the transmission line by a factor of  $f_0/f_1$ .

25 21. A planar inverted-F antenna (PIFA) comprising of:  
a rectangular top-plate, having a dimension L and a dimension W, a ground plane having dimensions larger than those of the top-plate, and a dielectric material between the top-plate and ground plane;

30 a feed pin connected to the top-plate somewhere within the top-plate's interior area of the top-plate;

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a first shorting pin and a second shorting pin connected between, and to, the top-plate and ground plane, such that the feed pin and two shorting pins form substantially a right angle whose edges are substantially perpendicular and parallel to an edge of the top-plate, and such that each shorting pin is a distance  $\rho$  from the feed pin; and

a length of transmission line connected to the end of the feed pin that is not connected to the top-plate.

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22. A communication device comprising:

a planar inverted-F antenna (PIFA) having a top plate, a ground plane, and a feed pin connected to the top plate, a first shorting pin and a second shorting pin, the first and second shorting pins connecting the top plate to the ground plane;

a power amplifier; and

a transmission line connecting the feed pin to the power amplifier.

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23. An offset top loaded monopole (TLM) comprising:

a top plate, a ground plane, a dielectric material between the top plate and the ground plane and a feed pin connected to the top plate substantially offset from the centre of the top plate to provide a desired impedance of the offset TLM at the feed pin.

24. The offset TLM of claim 23, wherein the feed pin is connected to a transmission line, the transmission line being used for fine-tuning of the offset TLM.

25. The offset TLM of claim 24, wherein the transmission line is connected to a power amplifier.
26. The offset TLM of claim 23 wherein a power amplifier is connected to the feed pin.
27. The offset TLM of claim 25, wherein the power amplifier is a broadband power amplifier.
- 10 28. The offset TLM of claim 23, wherein the dielectric material is air.
29. The offset TLM of claim 23, wherein the dielectric material is epoxy/glass.
- 15 30. The offset TLM of claim 23, wherein the dielectric material is alumina.
31. The offset TLM of claim 23, wherein the dielectric material is quartz.
- 20 32. The offset TLM of claim 23, wherein the dielectric material is polytetra fluoroethylene.
- 25 33. The offset TLM of claim 23 tuned at an operating frequency  $f_0$  and providing an inverse class-F load impedance.
34. The offset TLM of claim 24 wherein the transmission line is connected to a power amplifier.
- 30 35. The offset TLM of claim 34, wherein the power amplifier is a broadband power amplifier.

36. A method of tuning an offset top loaded monopole (TLM) to operate at an operating frequency  $f_0$  and to provide a inverse class-F impedance, the offset TLM having a top plate, a ground plane, a feed pin, a transmission line connected to the feed pin, the method comprising the steps of:

- a) varying the top plate position so that the feed pin is a maximal distance away from the center of the top plate;
- b) varying the height of the top plate above the ground plane to change the real part of the input impedance of the offset TLM, while respectively changing the imaginary part of the input impedance of the offset TLM; and
- c) adjusting the length of the transmission line to fine tune the input impedance of the offset TLM at  $f_0$  and to maintain the desired harmonic loading at the second and third harmonics of  $f_0$ .

37. A method of tuning an offset top loaded monopole (TLM) from a first operating frequency  $f_0$  to a second operating frequency  $f_1$ , the offset TLM having a top plate, a ground plane, a feed pin, a transmission line connected to the feed pin, the method comprising the steps of:

- a) scaling the height of the top plate above the ground plane by a factor of  $f_0/f_1$ ;
- b) scaling the area of the top plate by a factor of  $(f_0/f_1)^2$ ; and
- c) scaling the length of the transmission line by a factor of  $f_0/f_1$ .

38. An offset top loaded monopole (TLM) comprising of: a rectangular top-plate, having a dimension L and a dimension W, a ground plane having dimensions larger than

those of the top-plate, and a dielectric material sandwiched between the top-plate and ground plane;

a feed pin connected to the top-plate somewhere within the top-plate's interior area of the top-plate;

5 a length of transmission line connected to the end of the feed pin that is not connected to the top-plate.

39. A communication device comprising:

An offset top loaded monopole having a top plate,  
10 a ground plane, and a feed pin connected to the top plate;

a power amplifier; and

a transmission line connecting the feed pin to the power amplifier.